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(54) High pressure regulator valve.

(57) A pressure regulating valve for controlling pressure in high pressure hydraulic circuits includes a closure member (36) with an integral control piston (33) and a conical seating surface (38) cooperable with a complementary surface on a seat member (39). The valve closure member is biased in the closed position by an actuating mechanism including a pressure gas piston (88) and cylinder (72) arrangement utilizing a flexible diaphragm (90) for sealing the actuator pressure chamber (96). The effective cross-sectional area A_3 of the control piston is large enough to minimize the differences in cross-sectional areas on the closure member exposed to pressure fluid between the valve closed and valve open positions whereby a minimum variation between the valve opening pressure and the control pressure is experienced. The increase in pressure in the actuator pressure chamber (96) resulting from movement of the valve from the closed to open positions substantially offsets the change in effective face areas of the closure member to further minimize the difference between the valve opening pressure and the steady state regulated pressure.

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EUROPEAN SEARCH REPORT

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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
A	US-A-3 298 389 (FREEMAN) * Column 4, lines 10-25, figures 1,2 *	1	F 16 K 31/363 F 16 K 39/02
A	DE-A-2 625 555 (TEVES)		
A	AT-B- 265 787 (VOITH)		

TECHNICAL FIELDS SEARCHED (Int. Cl. ³)

F 16 K 31/00
F 16 K 39/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	30-08-1984	SCHLABBACH M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
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(54) **High pressure regulator valve.**

(57) A pressure regulating valve for controlling pressure in high pressure hydraulic circuits includes a closure member 36 with an integral control piston 33 and a conical seating surface 38 cooperable with a complementary surface on a seat member 39. The valve closure member is biased in the closed position by an actuating mechanism including a pressure gas piston 88 and cylinder 72 arrangement utilizing a flexible diaphragm 90 for sealing the actuator pressure chamber 96. The effective cross-sectional area A_3 of the control piston is large enough to minimize the differences in cross-sectional areas on the closure member exposed to pressure fluid between the valve closed and valve open positions whereby a minimum variation between the valve opening pressure and the control pressure is experienced. The increase in pressure in the actuator pressure chamber 96 resulting from movement of the valve from the closed to open positions substantially offsets the change in effective face areas of the closure member to further minimize the difference between the valve opening pressure and the steady state regulated pressure.

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HIGH PRESSURE REGULATOR VALVE

The present invention relates to a pressure regulator valve intended to minimize the variation between the valve opening pressure and the continuous operating pressure. The valve is particularly adapted for use in conjunction with high pressure liquid jet blasting or cutting apparatus.

In the development of high pressure hydraulic apparatus, such as water jet cutting and blast cleaning apparatus and hydrostatic test equipment, operating pressures have now commonly reached values in the range of 10,000 to 50,000 psig. The development of working liquid handling equipment operating in these pressure ranges presents special problems. In certain applications of water jet blast cleaning or cutting equipment, for example, it is desirable to regulate the pump discharge pressure to a substantially constant value regardless of the rate of usage of the pump flow. For example, it may be desired to have several on-off type nozzles or jetting guns connected to a single or common pump discharge line. In such an application it is desirable to provide a pressure regulating valve which will regulate the pump discharge pressure to a substantially constant value so that one or more guns may be properly operated from the same fluid source.

The high operating pressures of liquid jet blast cleaning or cutting equipment requires that the operating components be mechanically strong enough to

According to the invention from one aspect, there is provided a valve adapted for regulating relatively high hydraulic fluid pressures in a conduit, said pressures being in the range of at least 10,000 to 20,000 psig, said valve being characterised in that it includes a body defining a flow chamber, an inlet passage in communication with said chamber and adapted to be connected to said conduit, means forming a seat member including an outlet passage opening into said chamber and having a portion forming a seating surface, a valve closure member disposed in said chamber, said valve closure member comprising a portion engageable with said seating surface and a control piston connected to said closure member portion and including a portion slidably disposed in a bore in said body, said valve closure member including a first effective cross-sectional area exposed to fluid pressure in said chamber and responsive to said fluid pressure to urge said closure member to move away from said seating surface which is configured such that a second effective cross-section area of said closure member exposed to fluid pressure in said chamber upon movement of said closure member to the valve open position is no more than approximately ten percent greater than said first area, and actuator means for urging said control piston toward said closed position of said closure member.

a valve actuator connected to said body for providing a substantial biasing force acting on said control piston to urge said control piston toward said seating surface, said actuator including a pressure fluid cylinder, an actuating piston disposed in said cylinder and engaged with said control piston, a flexible diaphragm disposed in said cylinder and engaged with said actuating piston and defining a pressure fluid chamber for storing fluid under pressure to act on said actuating piston for urging said control piston to move said closure member to the valve closed position, a stop member disposed in said pressure fluid chamber for limiting the movement of said actuating piston in a direction to permit valve opening movement of said closure member whereby the volume of said pressure fluid chamber is reduced by a maximum amount to provide a pressure increase in said pressure fluid chamber sufficient to provide a valve closing force acting on said control piston which is substantially balanced by a valve opening force acting on said control piston;

said body and said actuating means being adapted to provide for removal of said closure member including said control piston from said body upon removal of said seat member from said body and without removal of the valve actuator providing said biasing force acting on said control piston.

The present invention provides an improved fluid pressure regulating valve particularly adapted for use in conjunction with high pressure liquid applications such as water jet cutting and blast cleaning equipment and hydrostatic testing equipment.

in pressure of the control fluid has minimal effect on the valve operating characteristics. In fact, the valve is adapted to provide a maximum change in volume of the control pressure fluid over the stroke length of the valve closure member which is operable to increase the control fluid pressure sufficiently to counteract the valve opening forces resulting from the change in effective area of the valve closure member when moving from the seated to the unseated position.

In one possible arrangement there is provided a valve biasing actuator for a high pressure regulating valve which is adapted to limit the opening movement of the valve closure member, control piston and actuator piston.

The high pressure regulator valve may adopt an improved arrangement of the component parts wherein a valve seat member and closure member are easily removable from the valve body for replacement or repair. In particular, in this case, the valve closure member and control piston which are formed as an integral part may be removed from the valve body and replaced without requiring disassembly or bleeding of control pressure fluid from the regulating actuator. The valve body and regulating actuator housing are of mechanically uncomplicated and rugged construction and the valve actuator pressure chamber is easily sealed by an improved cup shaped flexible diaphragm interposed between the actuator piston and the pressure chamber.

The invention will be better understood from the following description which refers, by way of example, to the accompanying drawings, in which :-

The gun 14 is operable to be actuated to supply a very high velocity stream of water to be used for cutting or blast cleaning in many applications known to those skilled in the art. In particular, the valve 20 is adapted to shutoff upon release of its actuating lever 21 to abruptly interrupt flow of high pressure water through the conduit 16. The apparatus illustrated in Figure 1 is adapted to be used in conjunction with one or several guns 14 although only one is shown for illustration purposes. Additional jet guns 14 could be used with the apparatus described and illustrated by merely connecting each additional gun to the conduit 16 in a manner readily understandable by those skilled in the art.

The apparatus illustrated in Figure 1 is adapted to be used in conjunction with an improved high pressure regulating valve, constituting a preferred embodiment of the present invention, and generally designated by the numeral 22. The valve 22 is also adapted to be connected to the pump discharge conduit 16 and is adapted to regulate the pressure in the conduit 16 by venting or dumping water through a valve discharge line 24 when the flow through the valve 20 is being throttled or completely shutoff. Basically, the pressure regulator valve 22 is adapted to maintain a substantially constant discharge pressure in the conduit 16 so that pressure variations do not occur at the guns 14 when in use and, particularly, if more than one gun is being used at the same time. The regulation of pressure to minimize the variation in pressure between the valve opening and operating condition is particularly advantageous in hydraulic jet blast cleaning or cutting systems as well as many other hydraulic systems including hydrostatic test equipment used for testing components such as piping, pressure vessels and other pressure fluid devices.

The body 26 includes an inlet conduit or passage portion 54 which is adapted to include a suitable threaded portion 55 for receiving a conduit fitting, not shown, for connecting the valve 22 to the pump discharge conduit 16 or other source of high pressure fluid. The seat 44 also includes a discharge flow passage 56 including a threaded portion formed in the head 52 to which a suitable fitting such as a relatively short pipe nipple 60 may be connected. A right angle fitting 62 is also suitably connected to the conduit portion 60 to redirect the discharge flow stream from the valve 22 through a discharge line such as the conduit 24.

In the development of a high pressure regulator valve for applications such as dumping or discharging substantially all of the output of a source of high pressure liquid the design criteria for the valve includes the sizing of the discharge passage 56 to be adequate such that a negligible pressure drop occurs through the passage when the valve is in the maximum open position. For example, for a valve adapted to operate between 10,000 and 20,000 psig inlet pressure in the passage 54 a 100 to 200 psig pressure drop through the passage 56 is considered negligible. Accordingly, once the flow area of the passage 56 has been determined it is then desirable to maximize the surface area of the valve seat surface which is designated by the numeral 64 in Figures 2 and 3. The valve seat surface 64 is formed as a frusto-conical surface delimited by the seat end wall 45 and the passage 56 and adapted to accommodate and be in sealing engagement with a cooperable seating surface 39 formed on the head 38 of the closure member 36.

It has been determined that it is desirable to maximize the actual surface area of the seating surface

stainless steel components for the valve closure member 36 and the seat 44, and included angle B of the conical surfaces 39 and 64 of between substantially 30° and 45°, and preferably 30° and 44°, will allow the closure member to move freely off of the seat surface under the urgning of pressure fluid at a design opening pressure of between 10,000 psig and 20,000 psig. This is a particularly important consideration in view of the fact that the force biasing the closure member in the closed position for a valve such as the valve 22 must be substantial when considering the operating pressures and the size of the valve required for typical flow volumes used in water jet cutting and cleaning operations.

The valve 22 is provided with an improved actuating mechanism for biasing the closure member 36 toward the closed position and for controlling the fluid pressure regulated by the valve. The actuating mechanism for the valve 22 includes a cylindrical piston type actuator which is disposed in an actuator housing comprising a cylinder member 70 characterized by a cylindrical steel tube having a bore 72. The cylinder 70 is located on the valve body 26 by a shoulder 74 machined into the end face 75 of the valve body and is retained in engagement with the valve body by a head member 76 and a plurality of elongated threaded tie rods 78. The tie rods 78 preferably comprise stud members which are threadedly engaged with a cylindrical collar 80 which is sleeved over the outer cylindrical surface 27 of the body 26 and butted against a transverse shoulder 82 opposite the shoulder 74. The head member 76 comprises a relatively heavy steel plate including one or more threaded passages such as the passages 84 and 86 formed therein. The head member 76 is retained in assembly with the cylinder 70 and body 26 by nuts 77 threadedly engaged with the tie rods 78.

10:1 and, accordingly, for a valve adapted to regulate the pressure in conduit 16 at 10,000 psi the chamber 96 is required to be charged with pressure fluid at a pressure of 1,000 psi. The chamber 96 may receive an initial charge of pressure fluid such as an inert gas at the desired pressure through the passage 84 which may be in communication with a conduit 104 having a constant pressure regulator valve 106 disposed therein and in communication with a source of pressure gas such as a tank 108. A suitable gas for use in the actuator of the valve 22 would be compressed air or nitrogen, for example. Although the chamber 96 may be initially charged with pressure gas at the desired pressure and cut off from the source such as the tank 108 it might be preferred in some applications to maintain a source of additional pressure gas onboard or in proximity to the valve 22 and controlled by a regulator such as the regulator 106. The passage 86 is provided for connecting the chamber 96 to a pressure gauge or indicator, not shown and would, of course, otherwise be plugged prior to charging the chamber 96.

Although the valve 22 is adapted to minimize the difference between the pressure required to open the valve and the pressure which is continuously regulated by the valve in a steady state condition, there is a net difference in these pressures as discussed previously herein. However, the actuator mechanism for the valve 22 is also adapted to minimize such pressure differences by providing the chamber 96 to be maintained at a minimum charge pressure by a regulator such as the regulator 106. However, the regulator 106 can be of a type which will allow the pressure to increase above the set point in the chamber 96 and, or course, this may occur upon movement of the piston 88 to decrease the

of the guns may be adjusted by setting the pressure in the chamber 96.

Although the construction of the valve 22 is such as to minimize the need for replacement or repair, the uncomplicated structural features of the valve facilitate ease of repair and/or replacement of the valve seat member 44 and the closure member 36, for example. The closure member 36 may, in fact, be replaced without disassembly of the actuator portion of the valve by simply removing the seat member 44 and allowing the closure member and the integral control piston 40 to be dropped or easily pulled out of the chamber 34. The diaphragm 90 is a longlife element and does not undergo severe cyclical distentions. In fact, for a valve sized to regulate a maximum of fifty gallons per minute of pump discharge flow, the diameter of the piston 88 may be a nominal 5.65 inches, the diameter of the control piston 40 may be a nominal 1.75 inches and the diameter of the discharge conduit 56 a nominal .45 inches. For a valve sized in accordance with the above described dimensions and a minimum pressure drop across the seat discharge passage of approximately 120 to 150 psig, the piston 88 will normally undergo movement of a maximum of .020 inches. Accordingly, this limited movement will not result in severe distention or compressing of the diaphragm 90.

Those skilled in the art will appreciate from the foregoing description that the valve 22 is mechanically uncomplicated and yet is provided with improved operating characteristics which are particularly desirable for applications in regulating pressures in relatively high pressure hydraulic applications.

2. A valve according to Claim 1, characterised in that said seating surface (64) comprises a frustoconical bore portion in said seat means (44), and said closure member (36) includes a conical portion (38) engageable with said seating surface (64), the included angle (B) of said conical portion being in the range of approximately 30° to 45° to prevent said closure member (36) from locking engagement with said seat means (44).

3. A valve according to claim 1 or 2, characterised in that the ratio of the first and second areas (A_3-A_2, A_3-A_1) is such as to provide a variation between opening pressure and operating pressure of five to ten percent.

4. A valve according to any preceding claim, characterised in that said actuating means comprises a pressure fluid cylinder (72, 76) an actuating piston (88) disposed in said cylinder, and a flexible cup shaped diaphragm (90) disposed in said cylinder and engaged with said actuating piston (88) and defining a pressure fluid chamber (96) for storing fluid under pressure to act on said actuating piston for urging said control piston (40) to move said closure member (36) to the valve closed position.

8. A valve according to any preceding claim, characterised in that said seat means includes a seat member (44) threadedly engaged with a cooperating threaded portion (28) of a bore (30) in said body defining said flow chamber (34), and said closure member (36) is retained in said body by said seat member (44).

9. A valve as claimed in claim 8, characterised by an annular seal member (42) disposed in said bore (30) defining said flow chamber (34) and in sealing engagement with said control piston (33) and with the bore wall of said flow chamber (34) to isolate said flow chamber (34) from said actuating means (72, 78, 80).

10. A valve adapted for regulating relatively high hydraulic fluid pressures in a conduit, said pressures being in the range of at least 10,000 to 20,000 psig, said valve being characterised in that it comprises :-

a body (26) having a first cylindrical bore (30) defining a flow chamber (34) and an inlet passage (54) in said body (26) opening into said flow chamber (34);

engaged with said control piston (33), a flexible diaphragm (90) disposed in said cylinder (70) and engaged with said actuating piston (88) and defining a pressure fluid chamber (96) for storing fluid under pressure to act on said actuating piston (88) for urging said control piston (33) to move said closure member (36) to the valve closed position, a stop member (98) disposed in said pressure fluid chamber (96) for limiting the movement of said actuating piston (88) in a direction to permit valve opening movement of said closure member (36) whereby the volume of said pressure fluid chamber (96) is reduced by a maximum amount to provide a pressure increase in said pressure fluid chamber (96) sufficient to provide a valve closing force acting on said control piston (33) which is substantially balanced by a valve opening force acting on said control piston (33);

said body (26) and said actuating means (72, 88, 90) being adapted to provide for removal of said closure member (36) including said control piston (33) from said body (26) upon removal of said seat member (44) from said body (26) and without removal of the valve actuator (72, 88, 90) providing said biasing force acting on said control piston (33).

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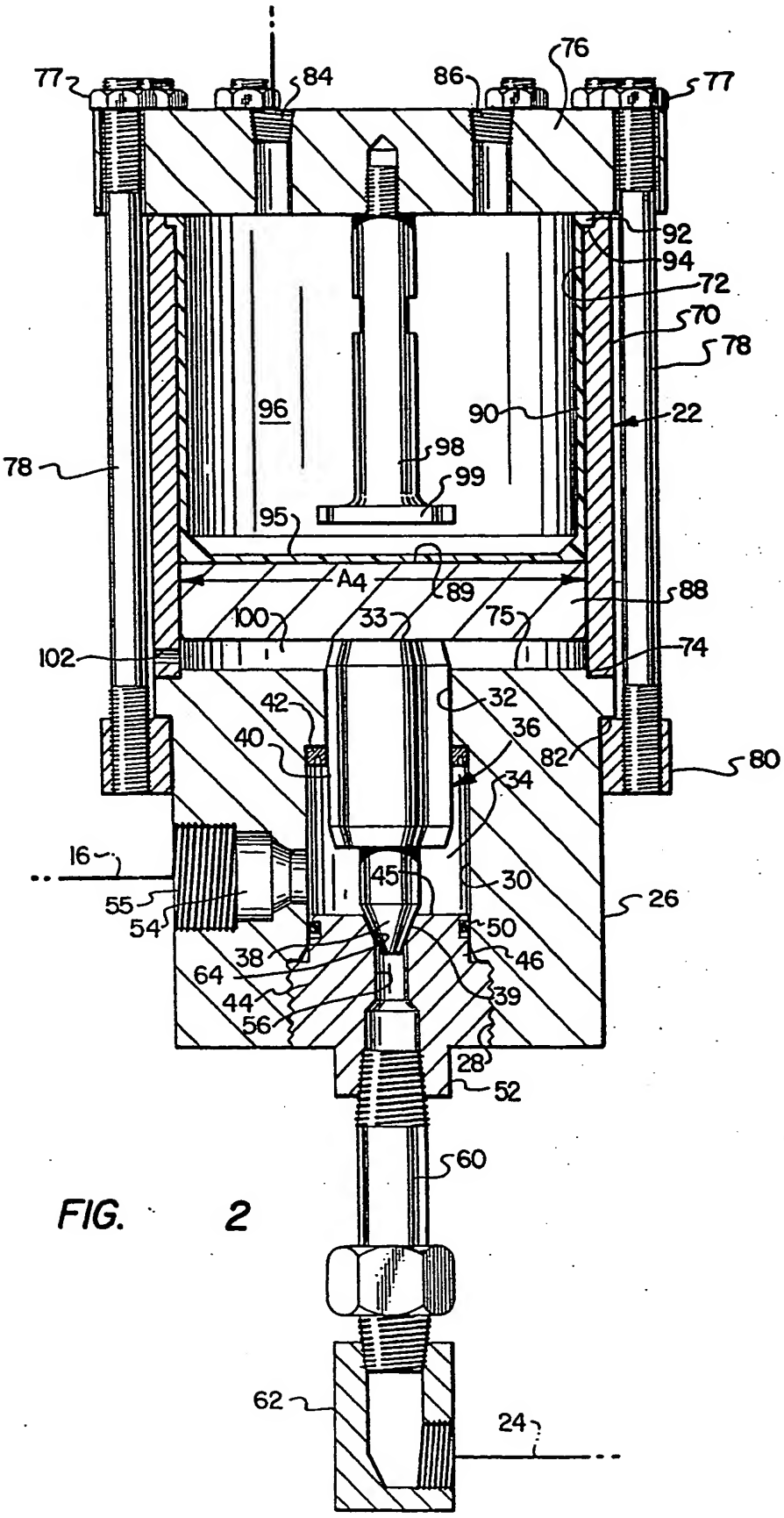

FIG. 2